Pulp Chips and Tanbark from Hemlock Slabs by Air-Flotation[1]

N. F. ROGER, E. L. GRIFFIN, JR., and C. S. REDFIELD

Eastern Regional Research Laboratory, Eastern Utilization Research Branch Agricultural Research Service, U. S. Department of Agriculture, Philadelphia, Pa.

and

W. H. KOEPP

Forest Products Research Division, Michigan College of Mining & Technology, Houghton, Mich.




Utilization of hemlock sawmill wastes is of dual interest: as a source of tannin materials and pulp chips. A process has been developed for separating hemlock slabs into a bark fraction suitable for tanning extraction and a wood fraction for pulping. A flow sheet and cost estimate for a proposed plant are presented.

FOR SEVERAL YEARS the U. S. Department of Agriculture has been actively engaged in the development of domestic tanning materials in an attempt to mitigate the almost complete dependence of our heavy leather industry on foreign sources of vegetable tannins (7, 17, 18, 20).[2] At the present time the equivalent of more than 100,000 tons of pure vegetable tanning materials are consumed (18) each year in this country, principally for the manufacture of leather. Only 20 years ago, fully 50% of this consumption was produced from domestic tanning raw materials: chestnut wood, oak bark, and eastern hemlock bark. The chestnut blight rendered commercial chestnut stands virtually extinct (5) while rising labor and transportation charges placed oak and hemlock bark in a less favorable competitive position with foreign tannin sources, resulting in our almost complete dependence on foreign vegetable tannin supplies as both raw and finished extracts.

Concurrently there is a tremendous increase in pulp and paper production which threatens to deplete our forest reserves. It is therefore necessary that we utilize forest resources more effectively. It has been said that we have potentially available, but unused, enough tannin-bearing barks within our borders to supply twice our needs and that there exists as sawmill waste enough wood fiber to supply much of our expanding pulpwood requirements (12). The wastes from some species such as hemlock, oak, Douglas-fir, and Sitka spruce can potentially supply both pulp chips and tanbark.

Recently progress has been made in utilizing heavy sawmill wastes, particularly with large mills of the far west (3) and south (10) which can finance the heavy investment of a saw log debarker. This, however, repre-

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[1] Presented by title only at Session III, Logging and Milling, Ninth National Meeting, FPRS, June 21–24, 1955, in Seattle, Wash.

[2] Numbers in parentheses refer to literature cited.

The Authors: Norman F. Roger holds B.S. from U. of New Hampshire, M.S. from U. of Pennsylvania, later attended U. of Delaware Extension School. He is a project leader working on development of domestic tanning materials at the Philadelphia laboratory.

Edward L. Griffin, Jr. is supervisor of tanning products development unit at the Eastern Utilization Research Branch, where he has carried out pilot plant studies since 1942. He holds B.Chem. and Chem. Eng. degrees from Cornell U.

Clifford S. Redfield, a graduate chemical engineer from M. I. T., is engaged in cost estimating and economic evaluation of processes at the Philadelphia laboratory.

Walter H. Koepp received A.B. from Northern Michigan College of Education, B.S. from U. of Michigan. He was associated with Ford Motor Co., Cleveland–Cliffs Oron Co., Lend Lease and Foreign Economic Administrations, North Africa Joint Economic Mission, and French Supply Council before joining faculty of Michigan College of Mining & Technology as Associate Professor. At present he is primarily interested in chemical utilization of Michigan woods.

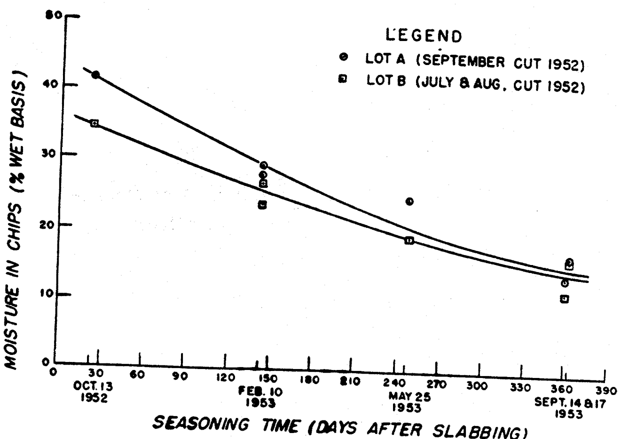

Fig. 1.—Air drying of banded 4-foot hemlock slabs.

sents only a fraction of the total potential in the south, northeast, and midwest where the small sawmills cut most of the lumber (12). Many methods of debarking sawmill wastes have been proposed and used in the past few years. Most are impractical, too expensive, or impair the use of tannin-bearing barks for extract manufacture.

The air-flotation method for the sorting of granular materials, first described by André (2), appears capable of satisfying the physical specifications of both the wood chip and tanbark products, namely, wood chips suitable for pulping and a bark-wood concentrate containing 10% tannin. This method, which depends on specific gravity differences as well as relative size and shape of the particles for efficient segregation (11), has been investigated for the recovery of oak bark from scrub oaks (4, 9), oak slabs and cordwood (21), and for the production of quality pulp chips from unbarked spruce (6).

Preliminary work on this study demonstrating the feasibility of segregating bark and wood chips from well seasoned eastern hemlock slabs and edgings has been reported (16). It remained to determine, however, what production conditions would be most practical, the seasoning time required to satisfy various aspects of the problem, and the production costs.

The development of a successful pulp cleaning device, the centri-cleaner[3] (15, 22), by the Hammermill Paper Co. and the Howard Smith Paper Mills Ltd. should promote the use of sawmill wastes for pulping by increasing the bark tolerance, and permit commercial sale of chips with a perceptible bark content, even for sulfite pulps.

Process

Seasoned hemlock slabs with attached bark are chipped in a manner effecting a detachment of bark and wood while producing pulp-type chips. The chips are screened into lots of uniform particle size and except for the fines, are segregated by air-flotation into bark and wood chip concentrates. The fines which are high in bark content are added directly to the bark concentrate.

Seasoning: The seasoning of the slabs is necessary for several reasons: seasoning is essential for good separation of the bark and wood during chipping, bark must be seasoned or cured to less than 20% moisture to prevent tannin deterioration by bacterial action during storage and to produce a quality extract.

Thirteen tons of 4-foot hemlock slabs were procured from the Northwoods Timber Co., Baraga, Mich. Two weeks after cutting, the slabs were banded into 400–500 pound bundles and shipped to Carthage, N. Y., for outside storage and periodic chipping tests. Only slabs with attached bark and wood were included for the test. It was estimated that 10 per cent by weight of the waste was bark-free wood which can be processed separately to produce pure wood chips.

The slabs consisted of two lots. Lot A was from trees felled in September 1952 after the close of the peeling season and Lot B was produced from trees felled in July and August 1952 during the peeling season. The banded slabs were stacked in two rows with the top covered by a tarpaulin to keep them free of snow and ice. Fig. 1 shows the rate of drying during one year's storage from the time of slabbing of the logs. It took more than 7 months' seasoning during winter and spring seasons to lower the moisture content of Lot B slabs below 20% and 9–10 months for Lot A.

Chipping: In these tests, two models of disc type slab chippers manufactured by the Carthage Machine Co., Carthage, N. Y., were used. Each has a horizontal power feeding device which stabilizes the slabs during chipping to produce chips with a uniform fiber length. The tilted disc model, Fig. 2, is such that the knife enters the bark and then the wood, giving the bark a differential thrust which apparently aids in detaching the bark from the wood. This can be seen in Fig. 3. The top slab shows the type of cutting action obtained with the tilted disc chipper.

In the vertical disc type chipper, lower slab Fig. 3, the knives enter the edge and cut diagonally across the slab, cutting both bark and wood simultaneously with no apparent differential action. Furthermore, this cutting action produced more wood fines and slivers which reduces both the pulp chip yield and the bark content of the fraction through 3-mesh.

The degree of detachment obtained with each chipper on both lots and the relative detachment obtained with respect to seasoning time and moisture content is shown in Table 1. Fig. 4 correlates detachment obtained with moisture content of the chips of both

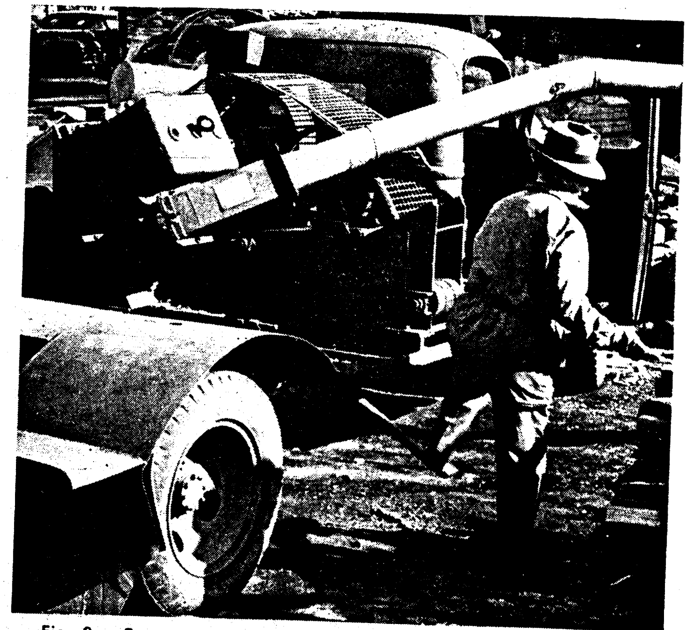
Fig. 2.—Experimental Carthage tilted disc portable slab chipper.


Fig. 3.—Slabs removed from chipper showing chipping action. Above: Tilted disc chipper; below: Vertical disc chipper.

[3] The mention of commercial products and companies anywhere in this paper does not imply that they are endorsed or recommended by the Department of Agriculture over others of a similar nature not mentioned.

Table 1.—CHIPPING TESTS ON SEASONED HEMLOCK SLABS

Date of Test	Days Seasoned Since Slabbing	Moisture Content When Chipped	Per cent by Weight Attached Bark and Wood: Lot A Felled in Sept. 1952, Tilted Disc Chipper	Lot A Felled in Sept. 1952, Vertical Disc Chipper	Lot B Felled July–Aug. 1952, Tilted Disc Chipper	Lot B Felled July–Aug. 1952, Vertical Disc Chipper
10/13/52	23	41.6	----	8.8	----	----
10/13/52	23	34.5	----	----	----	17.9
2/10/53	143	29.2	----	9.5	----	----
2/10/53	143	27.9	6.8	----	----	----
2/10/53	143	26.8	----	----	----	9.5
2/10/53	143	23.9	----	----	1.5	----
5/25/53	247	24.8	2.7	----	----	----
5/25/53	247	19.2	----	----	1.4	----
9/14/53	359	13.9	----	3.1	----	----
9/14/53	359	11.9	----	----	----	1.95
9/17/53	362	16.4	----	----	1.4	----
9/17/53	362	16.9	3.1	----	----	----
6/27/54	645	*	----	4.7	----	----
6/27/54	645	*	----	----	----	1.2
			Tilted Disc		Vertical Disc	
2/10/53	One-Year-Old†	20.7	3.2		---	
12/15/52	One-Year-Old†	17.1	---		3.3	
1/ 6/52	Over One-Year-Old‡	10.7	1.0		---	

*Samples not taken at time of chipping—believed to be below 15% moisture.
†Special lot about one-year-old; felling period unknown.
‡Special lot over one-year-old and stored under cover one month before chipping; felling period unknown.

lots immediately after chipping in both chippers. It was estimated that more than 3% by weight of attached bark and wood in the chips would prevent adequate segregation.

For Lot B (July and August 1952 fall), the same detachment was obtained for each of the three tests at 5-, 8- and 12-month seasoning when using the tilted disc chipper. A special lot (of unknown felling period) over one year old and held under cover for one month before chipping also gave excellent results on the tilted disc chipper.

As shown in Fig. 3, it appears that critical conditions exist below which greatly improved detachment was obtained with both chippers. The vertical disc chipper did not give as good results at the lower moisture contents as the tilted disc on Lot B (July and August fall). Both chippers gave equally good detachment on well seasoned Lot A slabs (September fall).

It was concluded in these tests that:

1. A slab chipper with a cutting action which imparts a differential impact force on the bark during chipping would give satisfactory detachment of bark and wood during chipping after only 8 months' seasoning but that a chipper with a less desirable cutting action might give adequate bark and wood separation on well seasoned slabs.
2. A seasoning time of 9–10 months in the open is required during the fall and winter seasons to reduce the moisture content in the bark below the safe storage limit of 20% moisture on the wet basis, although a storage starting during the late spring and summer months may give more rapid drying.
3. On trees felled at the close of the peeling season, a tightening of the bark occurs which makes bark separation more difficult even after a year's seasoning.

A typical screen analysis of the slab chips produced in the tilted disc slab chipper with the knives set to produce a ⅝″ fiber length chip is given in Table 2.

Air Flotation: Pilot-plant runs were made on samples of hemlock chips produced at Carthage, N. Y., to determine if segregation results previously reported (16) could be duplicated on slabs of known history under production conditions. In this process, the chips are screened into five fractions: retained on 1-inch, ¾-inch, 2-mesh, 3-mesh screens, and through a 3-mesh screen respectively. Under production conditions, the + 1″ overs would be sent to a rechipper and added to the chip stream to the screens although this was not done in these tests. The three middle fractions were floated separately on a model BX–100 Sutton Steele and Steele specific gravity separator (Fig. 5.)

Each flotation produced a wood fraction, a middle fraction, and a bark fraction. In the double pass process described in a preliminary paper (16), the middling fraction was refloated separately, resulting in secondary wood and bark fractions and a small middling portion. The wood product is made up of the wood fractions from each segregation combined. Similarly, the bark fractions are combined with the through 3-mesh fines to make up the bark product.

Previous results showed that the double pass system could produce a 99% pure wood product and an 80% bark product from well seasoned chips in good yield. Table 3 gives the results of a typical two-pass segregation run on hemlock slabs from trees felled in July and August and seasoned 8 months after slabbing before chipping in a tilted disc forced feed slab chipper. With these less seasoned slabs, it was only practical to produce a wood fraction containing 98% wood, but the bark fraction remained substantially the same, containing 81% bark.

Table 3.—TWO-PASS SEGREGATION OF BARK AND WOOD CHIPS FROM SEASONED HEMLOCK SLABS BY AIR-FLOTATION (RUN 3NH)*

Chips Segregated: Screen Fraction, Through Opening Inches	Screen Fraction, Retained On Opening Inches	% Retained	% Bark in Fraction	Feed to Separator Pounds	Wood Products: Chute 1 and 2, % of Total Chips	Chute 1 and 2, Bark Content %	Chute 3, % of Total Chips	Chute 3, Bark Content %	Middlings: Chute 3, % of Total Chips	Chute 3, Bark Content %	Chute 4, % of Total Chips	Chute 4, Bark Content %	Bark Products: Chute 4 and 5, % of Total Chips	Chute 4 and 5, Bark Content %	Chute 5, % of Total Chips	Chute 5, Bark Content %
-----	1.000	5.30	19.7	---	-----	----	----	----	-----	----	----	----	-----	----	----	----
1.000	0.645	35.23	33.0	394†	12.63	1.28	----	----	11.01	7.8	----	----	16.89	73.1	----	----
0.645	0.437	27.54	41.0	252	8.59	1.25	----	----	7.89	22.6	----	----	11.06	92.8	----	----
0.437	0.279	13.64	58.9	129	2.35	1.03	----	----	3.77	24.4	----	----	7.52	93.2	----	----
0.279	0.034	15.01	70.9	186											----	----
0.034	-----	3.28	96.4		-----	----	----	----	-----	----	----	----	-----	----	----	----
Total		100.00	46	961												
					Reflotation of Middlings (Chips from Chute 3 above)											
1.000	0.645	------	7.8	98	3.93	3.10	2.47	5.36	-----	----	4.61	20.2‡	-----	----	----	----
0.645	0.437	------	22.6	69	1.94	3.32	1.96	6.99	-----	----	3.57	33.3	-----	----	0.41	79.2
0.437	0.279	------	24.4	33	0.93	4.48	----	----	2.40	26.5	----	----	0.44	67.9	----	----
0.279 (not floated)		------	75.4	---	-----	----	----	----	-----	----	----	----	18.29	75.4	----	----
Composite Products, % of Feed				Wood:	30.37 34.80		4.43		2.40 Discards:	10.58	8.18		54.20 Bark:54.61		0.41	79.2
Composition of Products					98% Wood					73.9% Wood				81% Bark		

*Lot B Chips, 1.4% attachment.
†Includes fraction retained on 1.00″ screen.
‡Consists of Chutes 4 and 5.

Table 2.—TYPICAL SCREEN ANALYSIS OF SLAB CHIPS

Screen Size: Through	Screen Size: Over	Retained on Opening	Pounds Retained	% of Total	% Wood
-------	1"	1.00"	200.0	6.31	81
1"	¾"	0.645	928.5	29.32	68
¾"	2-mesh	0.437	901.8	28.45	58
2-mesh	3-mesh	0.279	514.5	16.23	45
3-mesh	20-mesh	0.034	510.5	16.11	30
20-mesh	-------	-----	114.0	3.60	12
Total			3169.3	100.00	54

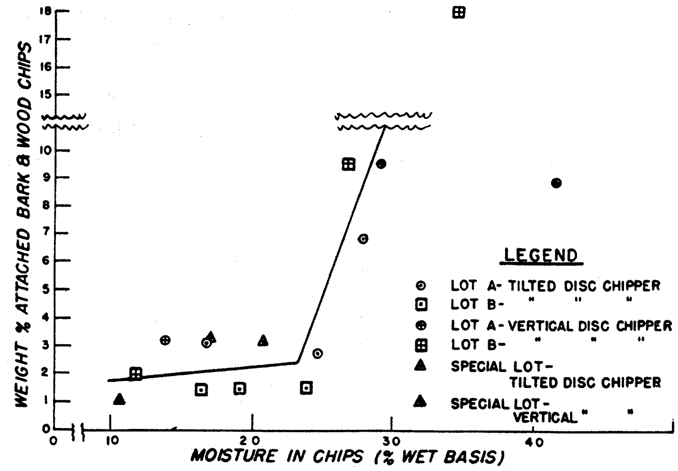

Fig. 4.—Correlation of the detachment of bark and wood obtained during chipping with moisture content of the chips.

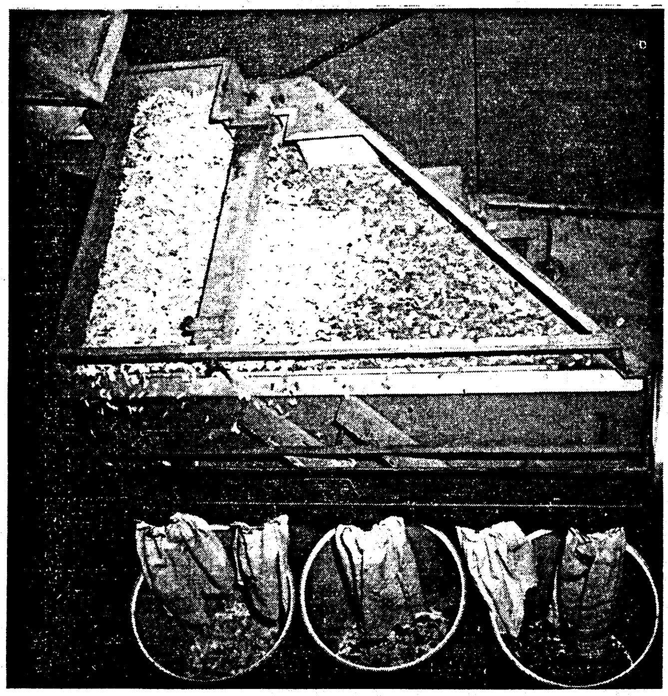

Fig. 5.—Air-flotation segregation of hemlock slab chips.

Table 4.—COMPARISON OF SEGREGATION EFFICIENCIES OF HEMLOCK CHIPS CUT FROM SEASONED SLABS IN A TILTED DISC CHIPPER*

Run	2NH†	3NH	5NH	6NH
Months Seasoning as Slabs	Over 1 year	8	12	5
Bark-Free Slabs Removed?	No	Yes	Yes	Yes
Bark Content %	36	46	46	45.5
Attached Bark and Wood % of Total Chips	1.0	1.4	1.4	1.5
Process Used	Two Pass	Two Pass	Two Pass	One Pass
Wood Product % of Feed	51.5	34.0	40	46.5
Composition of Wood Product % Wood	99	98	99	94.5
Bark Product % of Feed	39.7	54.6	50.2	53.1
Composition of Bark Product % Bark	78	81	83	80
Wood in Composite Wood Product % of Total Wood	77	65	72	80
Bark in Composite Bark Product % of Total Bark	92	93	92	94
Discarded % of Feed	8.8	10.6	9.8	0.4
Composition of Discard, % Wood	75.1	73.9	66.2	72.7

*Moisture of chips as floated 10–15% (on the wet basis).
†Reported in reference (16).

An additional run (No. 5NH) was made using the two-pass system on a 3200-pound lot of chips cut in the same chipper from the same lot of slabs, but after 12 months' seasoning. This run was made simulating production conditions. The results are summarized in Table 4 together with the results of other segregations for comparison. Both products were improved, containing 99% wood and 83% bark respectively with a slight decrease in discards.

The feasibility of producing a 95% wood product by using a single pass over the table was also investigated. Tests showed that a 95% wood chip product could be obtained directly with little or no discards while producing an 80% bark concentrate product as before. Results of such a run (No. 6NH) with chips similar to that used in other tests is shown in detail in Table 5 and are compared to the results of 2-pass runs in Table 4.

A 94.5% wood fraction and a 79.8% bark fraction were obtained with very little material discarded. Addition of chips from the bark-free slabs, normally representing 10% of the sawmill waste would yield a wood fraction containing about 95% wood. Thus, it is entirely feasible to use a one-pass system if a 95% wood fraction is acceptable for pulping. A flow diagram illustrating this process is shown in Fig. 6.

The bark and wood content in the slabs will vary markedly from lot to lot and will affect the quantity of each product as shown in Table 4. The efficiency of the segregation process is, therefore, best indicated by the relative amount of bark and wood recovered in the respective products and the amount discarded exclusive of knots which are undesirable in either product.

It is estimated that about 7–8% of the wood portion of hemlock slabs consists of knots which are removed from the wood product during the flotation process.

Evaluation of the Products

Wood Chips: The wood chip product of this segregation process should be an attractive raw material for both sulfite and kraft pulping where recently developed pulp cleaners are used. The almost complete removal of knots from the wood is particularly

Table 5.—SINGLE PASS SEGREGATION OF BARK AND WOOD CHIPS FROM SEASONED HEMLOCK SLABS BY AIR-FLOTATION (RUN 6NH)*

Chips Segregated: Screen Fraction: Through Opening Inches	Retained On Opening Inches	% Retained	% Bark In Fraction	Actual Feed to Separator lbs.	Wood Products Chute 1 and 2: % of Total Chips	Wood Products: Bark Content %	Middlings: % of Total Chips	Middlings: Bark Content %	Bark Products Chute 3, 4, 5: % of Total Chips	Bark Products: Bark Content %
-----	1.00	3.78	18.9	14	unprocessed		----	----	----	----
1.00	0.645	29.50	30.8	111	19.8	6.76	----	----	9.69	80.0
0.645	0.437	29.52	36.7	112	18.0	4.73	0.39†	28.0	11.1	88.8
0.437	0.279	17.04	55.2	74	6.2	5.55	----	----	10.9	83.5
0.279	0.034	17.52	71.2	77	(not floated)		----	----	20.2	74.3
0.034	-----	2.64	95.0							
Total		100.00	45.5	374	44.0		0.39		51.9	
Possible Recovery by Rechipping + 1" overs‡					2.5		0.02		1.3	
Composite Products					46.5		0.4		53.2	
Composition of Products					94.5% Wood		72.7% Wood		79.8% Bark	

*Lot B chips, 1.5% attachment.
†High concentration of knots removed at Chute 5.
‡Potential recovery by rechipping of +1" fraction based on the distribution of bark and wood obtained for the segregation of —1" fractions.

desirable in sulfite pulping because knots are not pulped by the sulfite liquor and are subsequently removed by the pulp screens. This will at least partly compensate for the loss in yield imposed by the residual bark compared to regular run chips which contain appreciable unpulpable knotty material.

Sulfite test sheets were made to determine the pulping qualities of a 99% and a 95% wood product. The results showed that even the 1% bark content was too high to produce a clean bleachable pulp; but after centricleaning (15, 22), each sample produced a bleached test sheet as strong and clean as sheets from regular run mill-peeled hemlock pulpwood. A normal amount of chlorine was required for bleaching in each case.

The 95% wood product required a somewhat larger discard of pulp screenings than normal while the 99% wood sample lost slightly less material on screening than the normal pulp. The tests indicated a shorter cooking cycle was desirable with these dry chips. (Test chips contained 10% moisture on wet basis). Use of dry chips from sawmill wastes will, therefore, require separate pulping. Since the pulp cleaner will be required in using both 99% wood chips and 95% wood chips, it would not be economical to operate the double flotation process and discard a part of the wood to obtain the higher purity.

Tanbark: The bark concentrate is a good hemlock tanning raw material and compares favorably with the traditional peeled hemlock bark which, years back, was the only tanning material many American tanners used to produce heavy leather. This vegetable tannin is still in demand although high bark handling and bark shipping costs have reduced its use in competition with foreign supplies. The tannin analysis (1) of various bark concentrates produced during these tests averaged about 10% on the moisture-free basis as shown in Table 6. The tannin contents of the pure barks are in the range of 12 to 14% as expected for commercial peeled Michigan hemlock bark (17). The tannin content of hemlock barks, however, varies with locality and age of the tree, location of sample on the tree, and may vary with the seasons (4).

The bark concentrate can be conveniently stored in bins or silos and can be conveyed by the usual methods. This should be a considerable advantage over the present high labor requirements for the handling and storage of peeled bark. Some further comminution of the bark retained on a 0.437″ opening (see bark product size distribution, Table 5), may be desirable. The 20% wood portion, although it contributes but little tannin to the sample, does facilitate bark handling by reducing the tendency to pack during extraction (8).

A local tanning extract manufacturer after analyzing a small sample of this bark product considered it an acceptable source of hemlock extract.

Costs

A cost estimate for the production of tanbark and pulp chips from hemlock slabs and edgings by the air-flotation method was made based on the single pass process capable of producing a 95% knot-free wood chip product and an 80% bark concentrate. Inasmuch as the development of pulp

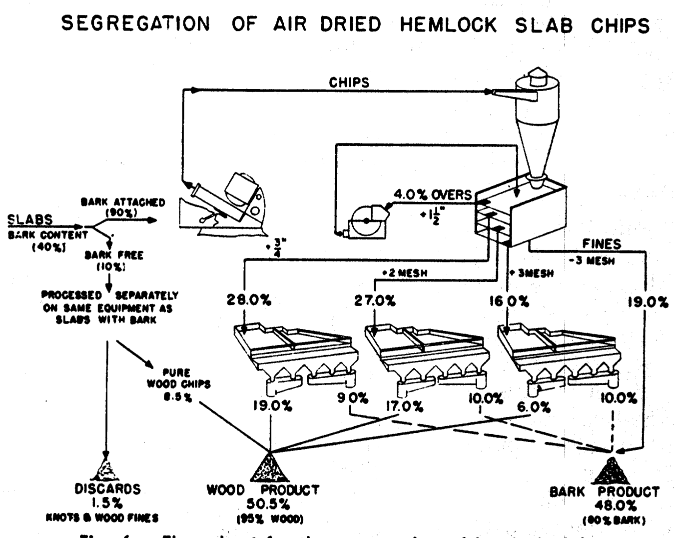

Fig. 6.—Flow sheet for the segregation of hemlock slab chips made from seasoned slabs.

Table 8.—EQUIPMENT SUMMARY

Item No.	Description	Price
1.	Belt conveyor—slab storage to chipper	$16,960.00
2.	Slab chipper—power fed—150 hp.	15,900.00
3.	Cyclone	2,000.00
4.	Hopper	180.00
5.	Vibrating chip screen, enclosed, 60 sq. ft., 2 deck, 1″ and ¾″ screens	3,940.00
6.	Vibrating chip screens, enclosed, 40 sq. st., 2 deck, 2 and 3 mesh screens	3,170.00
7.	Re-chipper—500 lbs./hr. capacity	700.00
8.	Hoppers—4 required	1,160.00
9.	Hoppers—3 required	950.00
10.	Specific gravity separators—size BXM-200—7 required	14,920.00
11.	Screw conveyors 6″—45′—2 required	2,540.00
12.	Screw conveyors 9″—50′—2 required	3,560.00
13.	Screw conveyors 4″—55′—2 required	2,300.00
14.	Screw conveyor 4″—23′	700.00
15.	Tank—wood 5′ diam. x 8′ deep	300.00
16.	Screw conveyor 10″—20′	1,000.00
17.	Screw conveyors 14″—22′	1,340.00
18.	Tank—wood 14′ diam. x 18′ deep	1,860.00
19.	Tank—wood 12′ diam. x 18′ deep	1,670.00
20.	Screw conveyor 9″—20′	830.00
21.	Tank—wood 12′ diam. x 18′ deep	1,560.00
22.	Concrete pits for tanks	2,740.00
23.	Pneumatic carloading equipment	2,880.00
		$83,160.00

Table 6.—TANNIN CONTENT OF BARK CONCENTRATES (MOISTURE-FREE BASIS)

Pilot Plant Run	% Bark in Concentrate	Soluble Solids %	Tannin %	Purity (Soluble Solids Basis)
2NH	78	15.59	10.33	66.3
3NH	81	14.24	9.44	66.3
5NH	83	14.97	10.16	67.9
6NH	80	14.24	9.22	64.8

Table 9.—COST SHEET

	Costs		
	Dollars Per Day	Dollars* Per Ton of Tanbark	Dollars Per Ton of Pulp Chips
1. Material—125 tons at $6.00/cord delivered—$5.45/ton	681.25		
2. Credit: 5.26 tons discards at $3.00/ton	—15.78		
Total material cost	665.47	3.661	7.321
3. Labor	240.00	1.320	2.640
4. Total prime cost	905.47	4.981	9.961
5. Indirect Labor			
a. Supervision	37.00	0.204	0.407
b. Watchmen	6.00	0.033	0.066
c. Mechanics	16.00	0.088	0.176
d. Office help	8.00	0.044	0.088
6. Indirect Expense			
a. Insurance, public liability and fire	8.80	0.048	0.097
b. Taxes	17.60	0.097	0.194
c. Interest on fixed capital	44.01	0.242	0.484
d. Depreciation	88.02	0.484	0.968
e. Social Security	4.25	0.023	0.047
f. Workmen's Compensation	3.51	0.019	0.039
g. Unemployment Insurance	17.50	0.096	0.192
h. Vacation time	12.28	0.068	0.135
i. Power	57.59	0.317	0.634
j. Steam (heating)	2.92	0.016	0.032
k. Maintenance repairs and renewals	40.09	0.221	0.441
l. Gasoline	6.25	0.034	0.069
m. Factory supplies	6.01	0.033	0.066
n. Miscellaneous factory expense	10.00	0.055	0.110
7. Total Factory Overhead	385.83	2.122	4.245
8. Factory Cost	1291.30	7.103	14.206
9. Interest on working capital	19.99	0.110	0.220
10. Administration and General Expense	48.47	0.267	0.533
11. Cost to make	1359.76	7.480	14.959
12. Selling Cost	90.89	0.500	1.000
13. Cost to make and sell	1450.65	7.980	15.959

*Assumes value of tanbark to be ½ that of pulp chips. All tons are short tons of 2000 pounds.

cleaning devices has been shown to be capable of cleaning pulps made from chips containing small amounts of bark, it is felt that a wood chip product containing about 5% bark would compare in pulp yield to regular run chips containing about the same amount of knots.

This cost estimate assumes that the slab processing plant is to be a new and independent enterprise, even though, it is realized, it should logically be operated in connection with a pulp mill or, better still, a tannin extraction plant. It is assumed that the proposed slab processing facilities will have a capacity of 125 short tons of slabs per day operating 24 hours per day and 300 days per year. The slabs will be obtained from sawmills in a 100–150-mile radius of the plant. The sawmill will band 4-foot slabs and edging into 1/4 to 1/2-cord bundles and store them in the open for 9–10 months before shipping to the slab segregation plant. It is estimated the slabs will cost $6 per cord delivered and on the basis that one cord of air-dried slabs produces 2,200 pounds of chips, the raw material cost of the chips will be $5.45 per short ton.

A flow sheet of the process, Fig. 6, shows the relative quantities of chips at each stage of the operation while operating on typical slabs. It is assumed that 10% of the slabs and edgings will be bark-free. This portion will be run separately to produce pure knot-free chips upgrading the overall wood product. A yield of 85% of the bark-free slabs is assumed. This is based on a knot content of 7.5% and the production of 7.5% wood fines during chipping. For the normal slabs with attached bark, a 97% yield was assumed for the cost estimate, allowing 3% for losses or discards of small portions as required to maintain the required purity of the products. This gives a production of 62.04 short tons of wood chips, 57.7 short tons of tanbark, and 5.26 tons of discards per day.

Table 7 lists the capital costs for a 125-ton-per-day plant erected in the Upper Peninsula Michigan Area; Table 8 summarizes the equipment required with estimated costs; and Table 9 gives estimates of production costs based on a 300-day year, 24-hour per day operation.

The respective production costs of the tanbark and pulp chips produced are figured on the basis that the pulp chips have twice the market value of the tanbark. Therefore, they must carry the greater part of the costs since the costs solely attributable to the bark fraction are low.

Assuming the pulp chips and tanbark have a sale value of $20 and

Table 7.—CAPITAL COSTS

Land and site preparation—3 acres	$ 1,500.00
Roads and parking areas	11,800.00
Railroad siding, 1000 ft.	9,000.00
Buildings	41,140.00
Boilers for heating	1,200.00
Equipment—manufacturing	83,160.00
Erection of equipment—manufacturing	20,780.00
Piping and ductwork	5,820.00
Erection of piping and ductwork	3,490.00
Heating—installed	2,330.00
Lighting—installed	1,960.00
Power—installed	8,770.00
Transportation facilities—slab handling	18,000.00
Freight on equipment	1,600.00
Office furniture and fixtures	800.00
Contingencies	26,400.00
Engineering fees	26,400.00
Total fixed capital	$264,150.00
Working capital	$120,000.00
Total capital	$384,150.00

$10 per short ton f.o.b. plant respectively, the annual net sales would be $534,000, giving a gross annual profit of $147,000 which, after deducting the usual administration, research and selling expense, and income tax, gives a net return of $47,500, or approximately 18% return on the fixed capital investment.

Cost estimates for the 2-pass flotation process which yields a 98–99% wood fraction show this process to be less attractive since this wood product probably could not sell at a sufficient premium over the 95% product to compensate for the lower wood yield obtained and the additional equipment and processing costs entailed in the second flotation.

Conclusion

Under current economic conditions, the utilization of hemlock sawmill wastes in the Upper Peninsula Michigan Area is dependent on the utilization of the bark as well as the wood portion of the slab because the bark represents about 40–50% of the waste. The air-flotation method can be economically operated to produce a pulp chip product which should prove acceptable for sulfite and kraft pulp making provided a market for the bark product can be obtained. This will require the erection of bark extraction facilities in the area. Market surveys have shown there is sufficient demand for hemlock extract to assure the sale of extract produced on this scale. Such an extraction plant would also have available large quantities of peeled hemlock bark produced nearby as a pulpwood byproduct. This extract plant would be in an excellent location to supply tanneries in the Lake States and the midwestern areas.

Acknowledgment

The authors are indebted to the Carthage Machine Co. for assistance in conducting the chipping tests, to Howard Smith Paper Ltd. of Cornwall, Ont., for loan of their portable slab chipper, to Mrs. M. L. Happich and Mrs. M. S. Gaspar for analyses, and to R. K. Eskew for general guidance in the work.

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